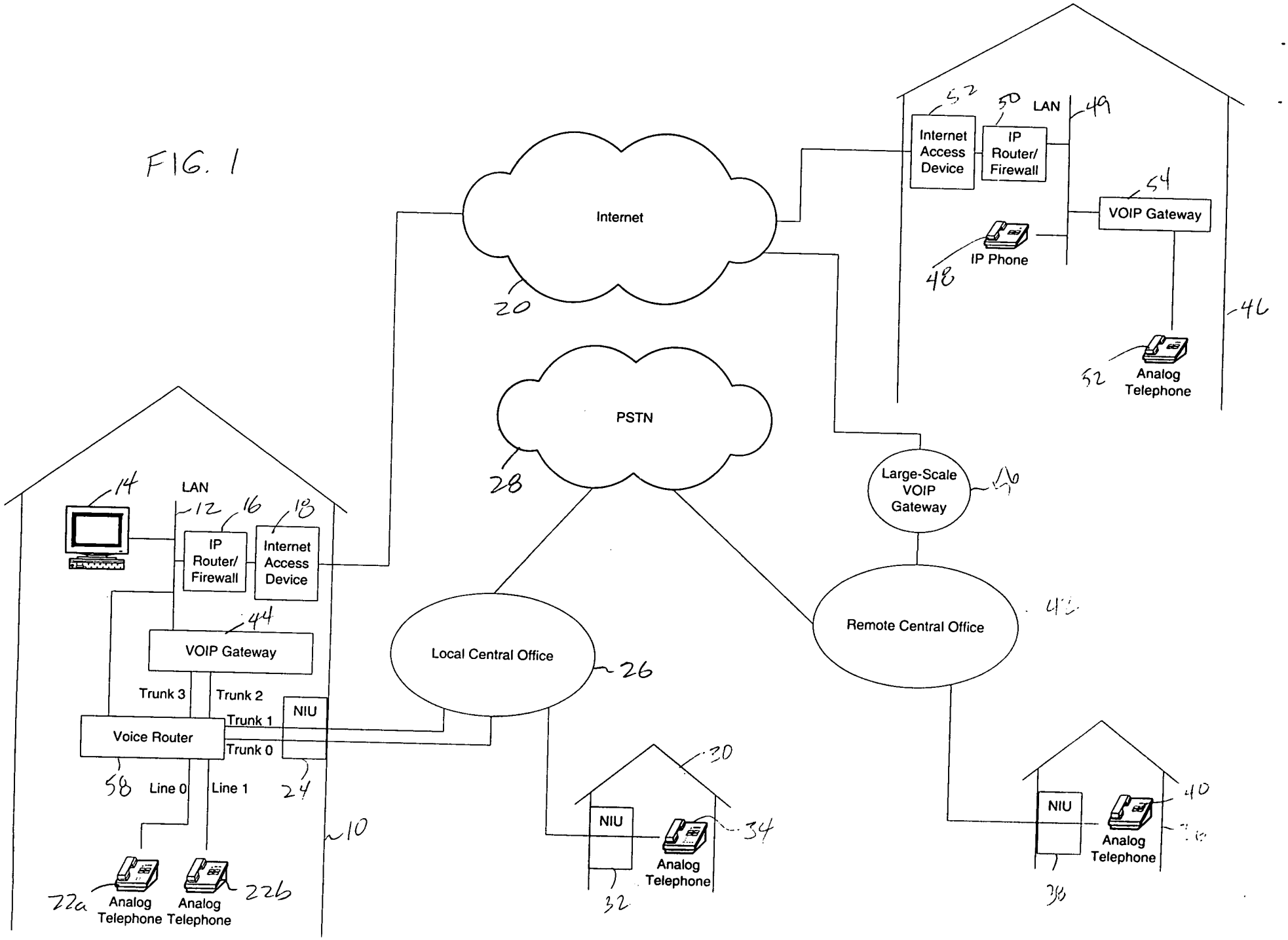
FIG. 1


Internet
20
PSTN
28
Internet Access Device
52
IP Router/ Firewall
50
LAN
49
VOIP Gateway
54
IP Phone
48
46
Analog Telephone
52
Large-Scale VOIP Gateway
Remote Central Office
Local Central Office
26
14
LAN
12
IP Router/ Firewall
16
Internet Access Device
18
VOIP Gateway
44
Trunk 3
Trunk 2
Trunk 1
Trunk 0
NIU
Voice Router
58
Line 0
Line 1
24
10
22a
Analog Telephone
Analog Telephone
22b
30
NIU
Analog Telephone
34
32
NIU
Analog Telephone
40
38

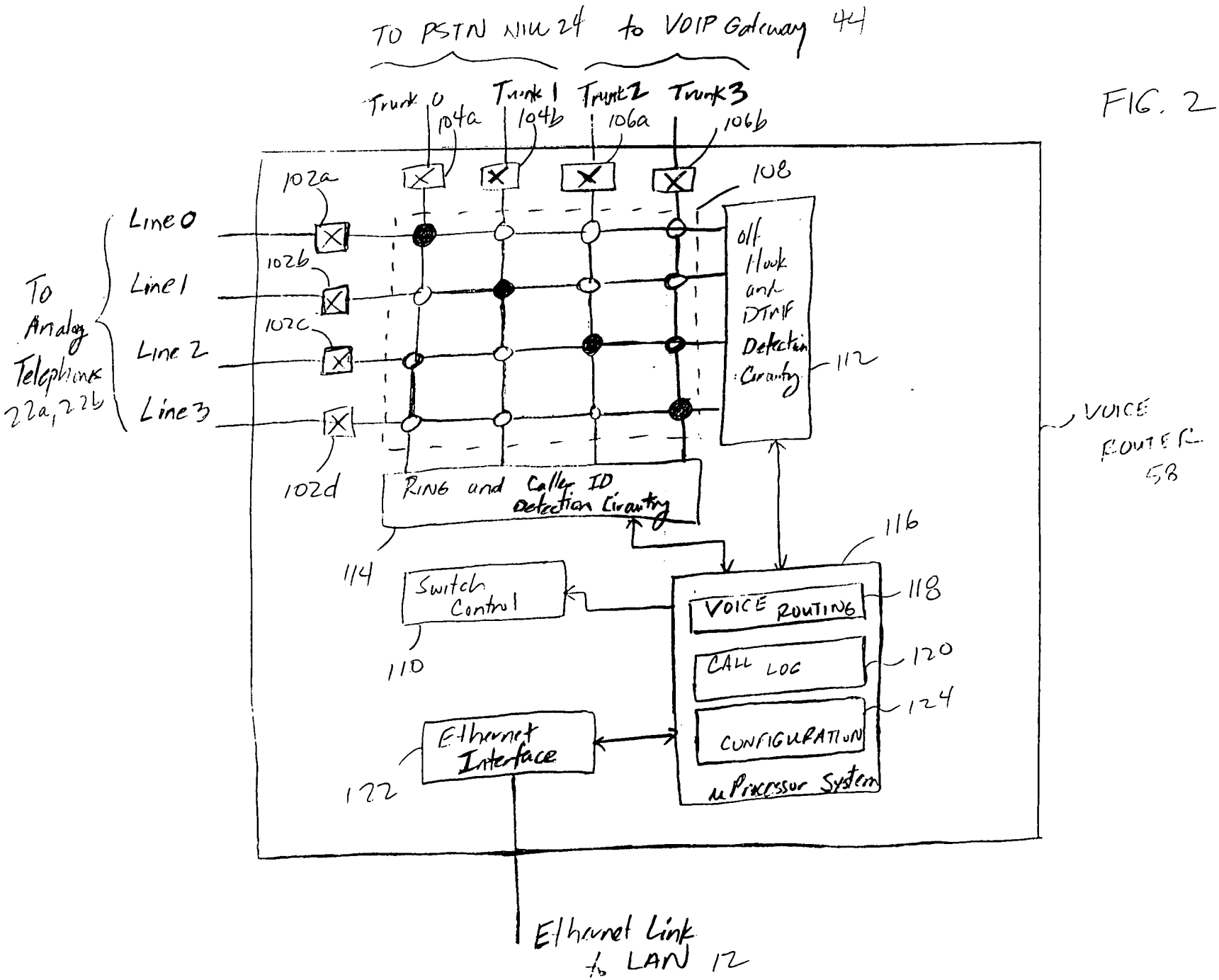

TO PSTN NIU 24
to VOIP Gateway 44
Trunk 0
Trunk 1
Trunk 2
Trunk 3
104a
104b
106a
106b
102a
102b
102c
102d
108
Line 0
Line 1
Line 2
Line 3
To Analog Telephones 22a, 22b
Off Hook and DTMF Detection Circuitry
112
RING and Caller ID detection Circuitry
114
VOICE ROUTER 58
116
Switch Control
110
VOICE ROUTING
118
CALL LOG
120
CONFIGURATION
124
Ethernet Interface
122
uProcessor System
Ethernet Link to LAN 12

FIG. 2

Inbound Routing Table

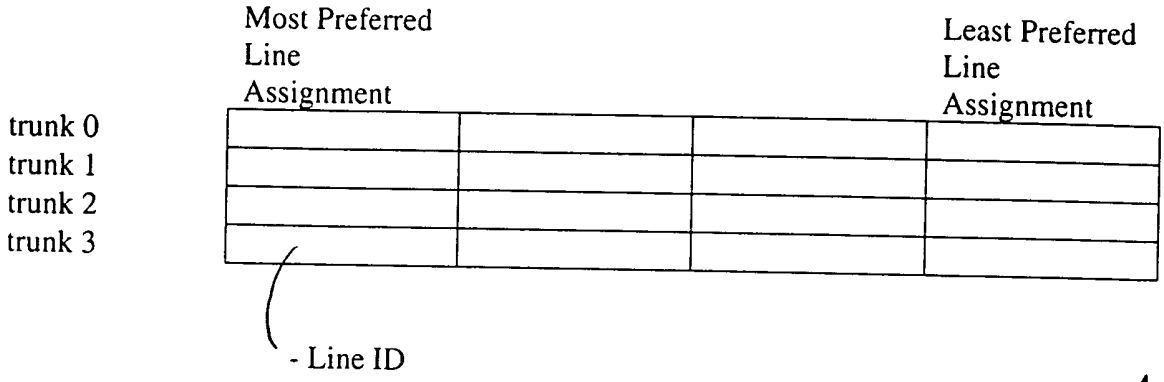


FIG. 3A

- Group of one or more Line IDs
  (each Line of the Group rings concurrently)

- Ordered Groups of one or more Line IDs
  (if any line of "most preferred group" is unavailable, proceed to next Group; for "first available" Group, each Line of this Group rings concurrently)

First Exemplary Inbound Routing Table

0	1	2	3
1	0	2	3
2	3	1	0
3	3	1	0

FIG. 3B

Second Exemplary Inbound Routing Table

0	1	2	3
(0,1)	2	3	FF
(0,1), (1,2)	3	1	FF
3	3	1	0

FIG. 3C

Outbound Routing Table

	Most Preferred Trunk Assignment			Least Preferred Trunk Assignment
line 0				
line 1				
line 2				
line 3				

Trunk ID

FIG 4A

First Exemplary Type 1 (Local) Outbound Routing Table

1	0	2	3
1	0	2	3
1	0	2	3
1	0	2	3

FIG. 4B

First Exemplary Type 2 (Long Distance) Routing Table

2	3	1	0
2	3	1	0
2	3	1	0
2	3	1	0

FIG 4C

Second Exemplary Type 1 (Local) Outbound Routing Table

0	1	FF	FF
1	0	FF	FF
1	0	FF	FF
1	0	FF	FF

FIG 4D

Second Exemplary Type 2 (Long Distance) Outbound Routing Table

3	2	FF	FF
3	2	FF	FF
3	2	FF	FF
3	2	FF	FF

FIG 4E

Trunk Ownership Data Structure for a given Trunk

Active Status Field (bit 7) '1' = Active (A) '0' = Inactive (I)	Optimization Status Field (bit 6) '1' = Currently Being Optimized (OP) '0' = Not Being Optimized (NOP)	If Active, then (bits 5-0) = Owning Call Object ID If Inactive, then (bits 5 - 0) = Default Trunk ID

FIG. 5A

Line Ownership Data Structure for a given Line

Active Status Field (bit 7) '1' = Active (A) '0' = Inactive (I)	Optimization Status Field (bit 6) '1' = Currently Being Optimized (OP) '0' = Not Being Optimized (NOP)	If Active, then (bits 5-0) = Owning Call Object ID If Inactive and NOP, then (bits 5-0) = Trunk ID for Inbound and Outbound Call Processing

FIG. 5B

FIG. 6

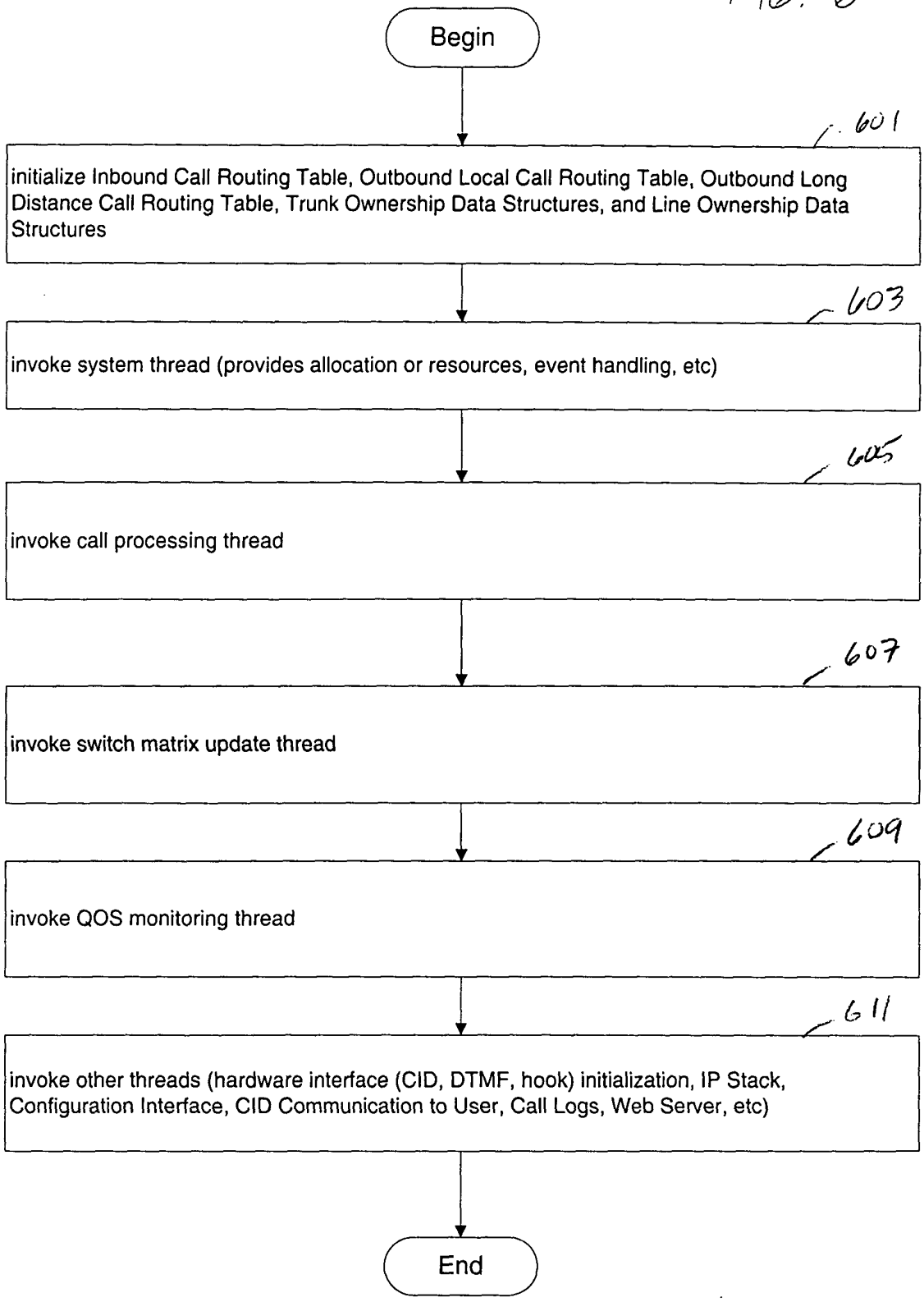

Begin
601
initialize Inbound Call Routing Table, Outbound Local Call Routing Table, Outbound Long Distance Call Routing Table, Trunk Ownership Data Structures, and Line Ownership Data Structures
603
invoke system thread (provides allocation or resources, event handling, etc)
605
invoke call processing thread
607
invoke switch matrix update thread
609
invoke QOS monitoring thread
611
invoke other threads (hardware interface (CID, DTMF, hook) initialization, IP Stack, Configuration Interface, CID Communication to User, Call Logs, Web Server, etc)
End

FIG. 7A

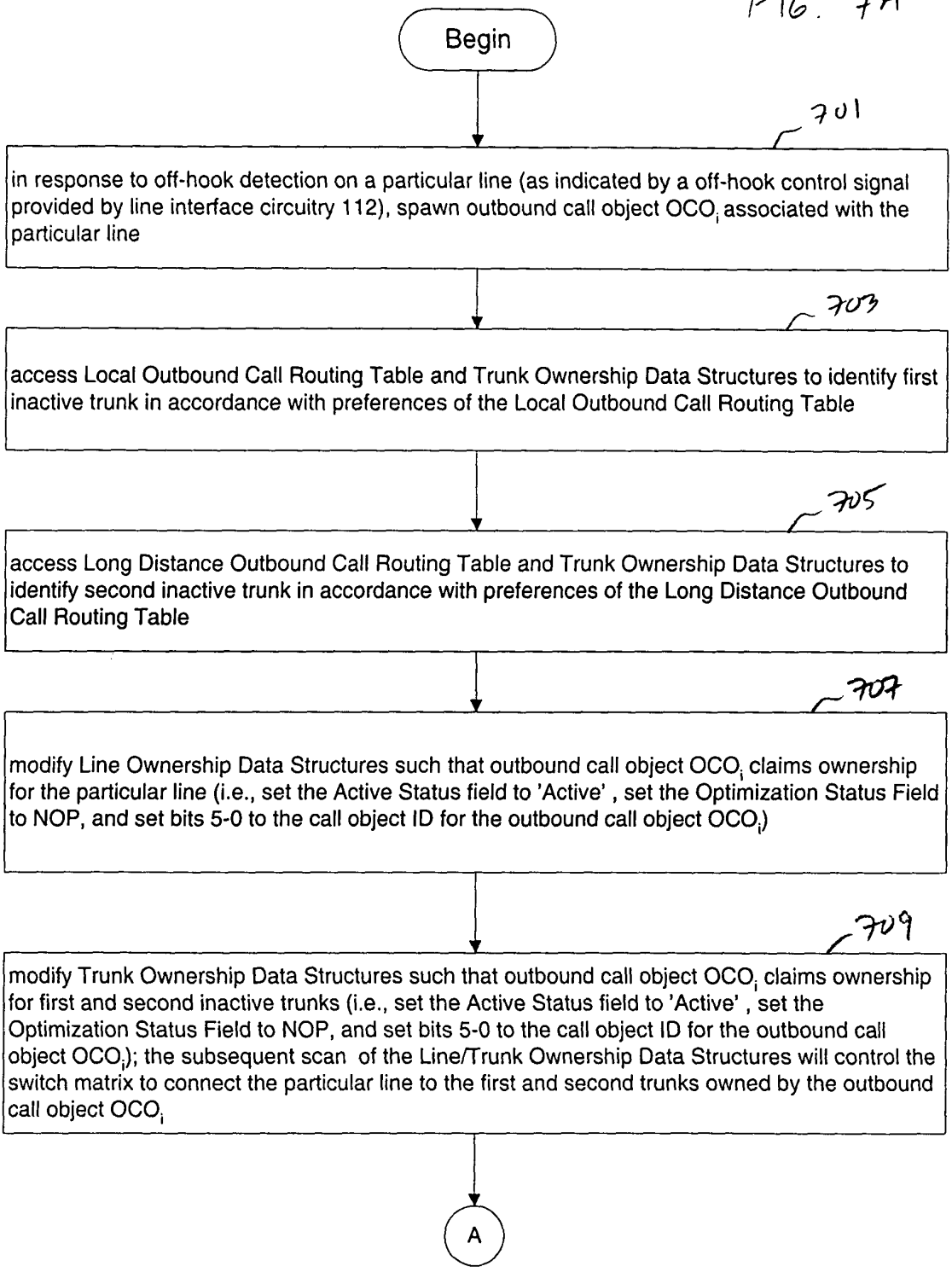

Begin
701
in response to off-hook detection on a particular line (as indicated by a off-hook control signal provided by line interface circuitry 112), spawn outbound call object OCO_i associated with the particular line
703
access Local Outbound Call Routing Table and Trunk Ownership Data Structures to identify first inactive trunk in accordance with preferences of the Local Outbound Call Routing Table
705
access Long Distance Outbound Call Routing Table and Trunk Ownership Data Structures to identify second inactive trunk in accordance with preferences of the Long Distance Outbound Call Routing Table
707
modify Line Ownership Data Structures such that outbound call object OCO_i claims ownership for the particular line (i.e., set the Active Status field to 'Active' , set the Optimization Status Field to NOP, and set bits 5-0 to the call object ID for the outbound call object OCO_i)
709
modify Trunk Ownership Data Structures such that outbound call object OCO_i claims ownership for first and second inactive trunks (i.e., set the Active Status field to 'Active' , set the Optimization Status Field to NOP, and set bits 5-0 to the call object ID for the outbound call object OCO_i); the subsequent scan of the Line/Trunk Ownership Data Structures will control the switch matrix to connect the particular line to the first and second trunks owned by the outbound call object OCO_i
A

FIG 7B

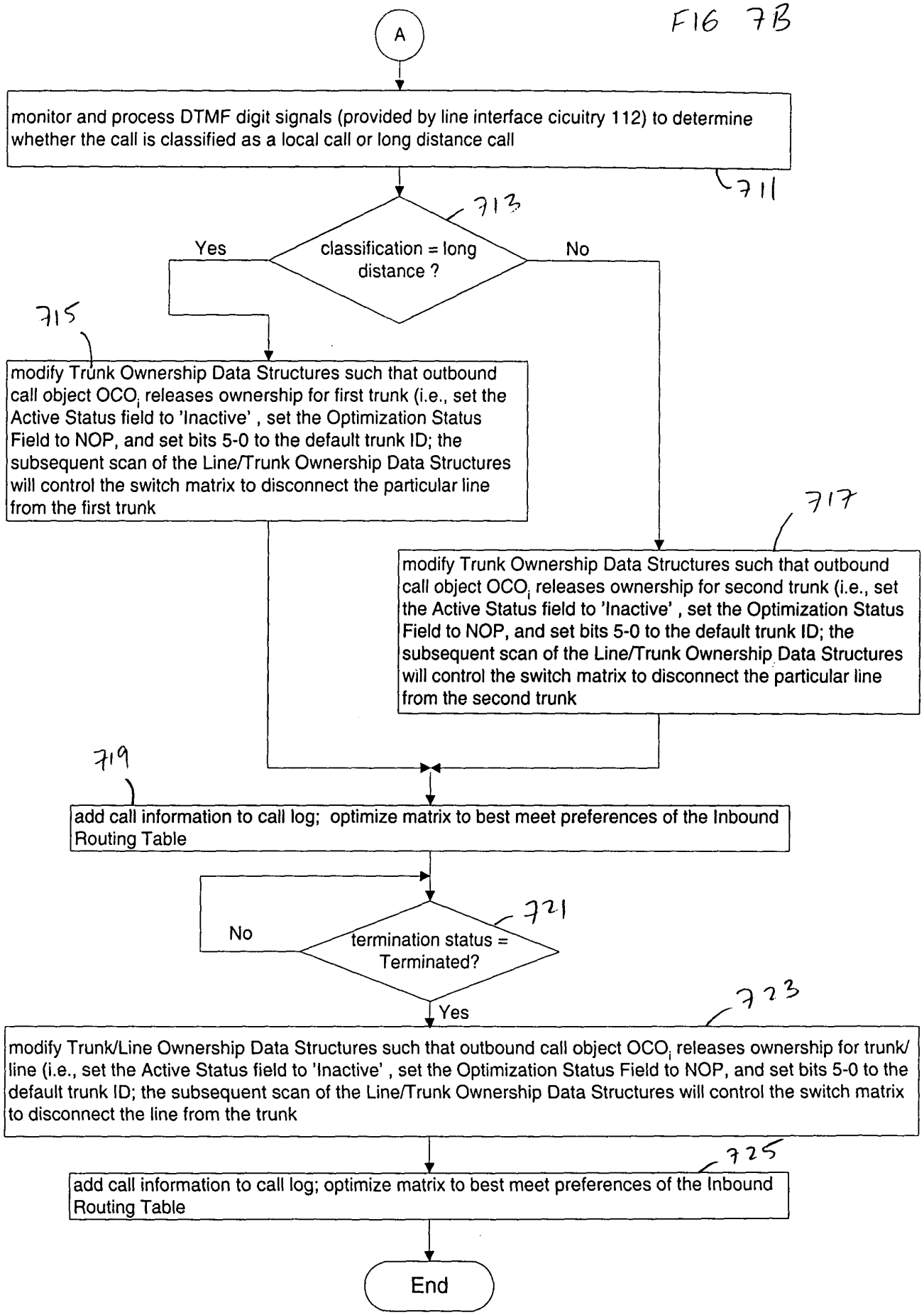

A
monitor and process DTMF digit signals (provided by line interface cicuitry 112) to determine whether the call is classified as a local call or long distance call
711
713
classification = long distance ?
Yes
No
715
modify Trunk Ownership Data Structures such that outbound call object OCO$_i$ releases ownership for first trunk (i.e., set the Active Status field to 'Inactive' , set the Optimization Status Field to NOP, and set bits 5-0 to the default trunk ID; the subsequent scan of the Line/Trunk Ownership Data Structures will control the switch matrix to disconnect the particular line from the first trunk
717
modify Trunk Ownership Data Structures such that outbound call object OCO$_i$ releases ownership for second trunk (i.e., set the Active Status field to 'Inactive' , set the Optimization Status Field to NOP, and set bits 5-0 to the default trunk ID; the subsequent scan of the Line/Trunk Ownership Data Structures will control the switch matrix to disconnect the particular line from the second trunk
719
add call information to call log; optimize matrix to best meet preferences of the Inbound Routing Table
721
No
termination status = Terminated?
Yes
723
modify Trunk/Line Ownership Data Structures such that outbound call object OCO$_i$ releases ownership for trunk/line (i.e., set the Active Status field to 'Inactive' , set the Optimization Status Field to NOP, and set bits 5-0 to the default trunk ID; the subsequent scan of the Line/Trunk Ownership Data Structures will control the switch matrix to disconnect the line from the trunk
725
add call information to call log; optimize matrix to best meet preferences of the Inbound Routing Table
End

FIG 8A

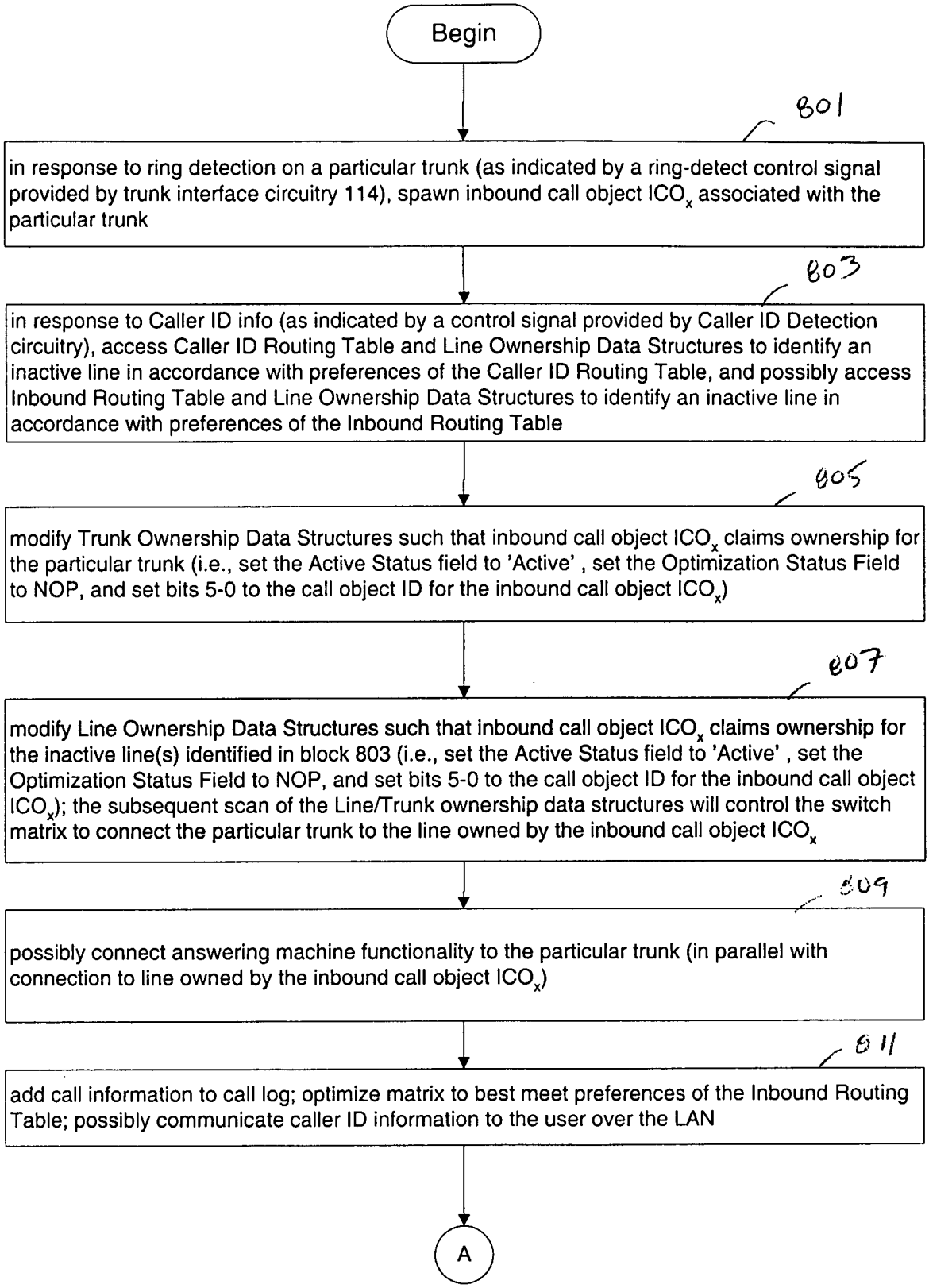

Begin
801
in response to ring detection on a particular trunk (as indicated by a ring-detect control signal provided by trunk interface circuitry 114), spawn inbound call object ICO_x associated with the particular trunk
803
in response to Caller ID info (as indicated by a control signal provided by Caller ID Detection circuitry), access Caller ID Routing Table and Line Ownership Data Structures to identify an inactive line in accordance with preferences of the Caller ID Routing Table, and possibly access Inbound Routing Table and Line Ownership Data Structures to identify an inactive line in accordance with preferences of the Inbound Routing Table
805
modify Trunk Ownership Data Structures such that inbound call object ICO_x claims ownership for the particular trunk (i.e., set the Active Status field to 'Active' , set the Optimization Status Field to NOP, and set bits 5-0 to the call object ID for the inbound call object ICO_x)
807
modify Line Ownership Data Structures such that inbound call object ICO_x claims ownership for the inactive line(s) identified in block 803 (i.e., set the Active Status field to 'Active' , set the Optimization Status Field to NOP, and set bits 5-0 to the call object ID for the inbound call object ICO_x); the subsequent scan of the Line/Trunk ownership data structures will control the switch matrix to connect the particular trunk to the line owned by the inbound call object ICO_x
809
possibly connect answering machine functionality to the particular trunk (in parallel with connection to line owned by the inbound call object ICO_x)
811
add call information to call log; optimize matrix to best meet preferences of the Inbound Routing Table; possibly communicate caller ID information to the user over the LAN
A

FIG 8B

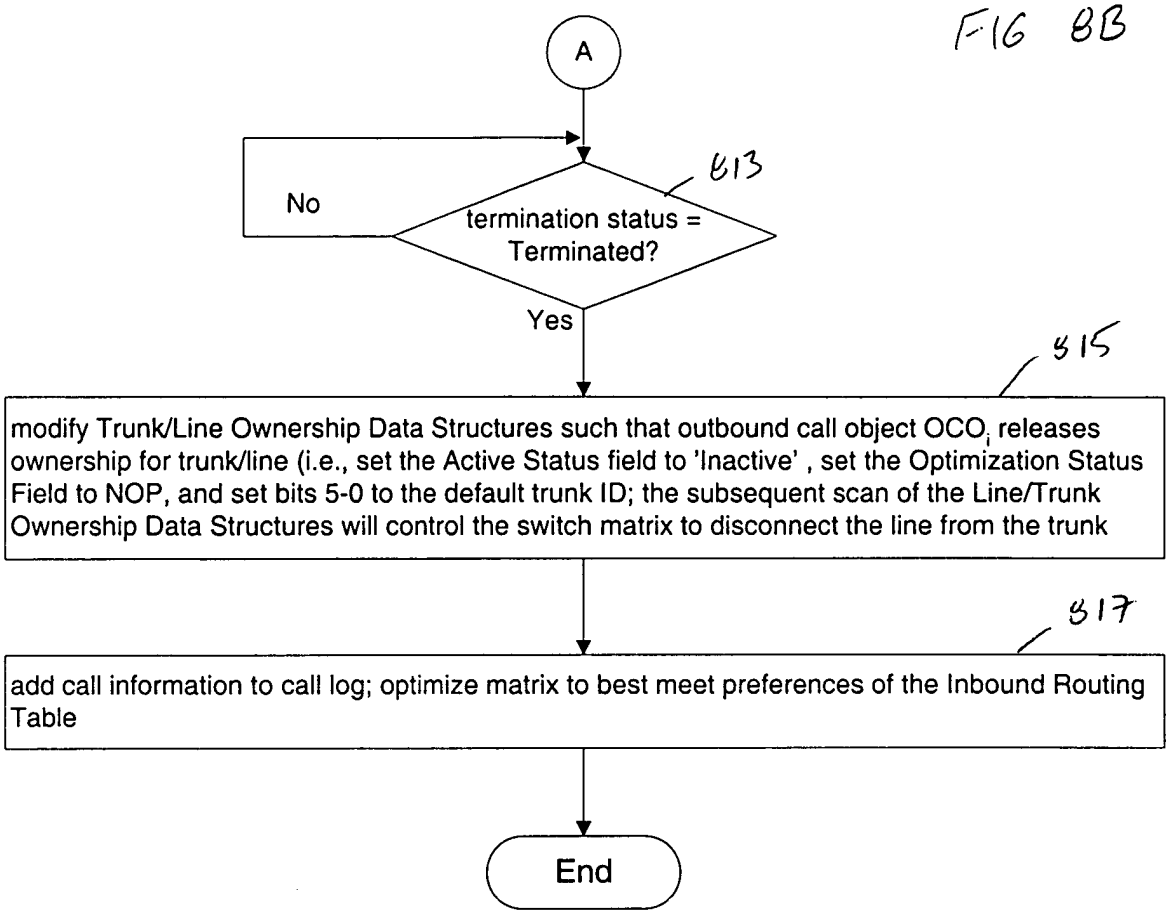

A
613
No
termination status = Terminated?
Yes
615
modify Trunk/Line Ownership Data Structures such that outbound call object OCO_i releases ownership for trunk/line (i.e., set the Active Status field to 'Inactive' , set the Optimization Status Field to NOP, and set bits 5-0 to the default trunk ID; the subsequent scan of the Line/Trunk Ownership Data Structures will control the switch matrix to disconnect the line from the trunk
617
add call information to call log; optimize matrix to best meet preferences of the Inbound Routing Table
End

FIG 9

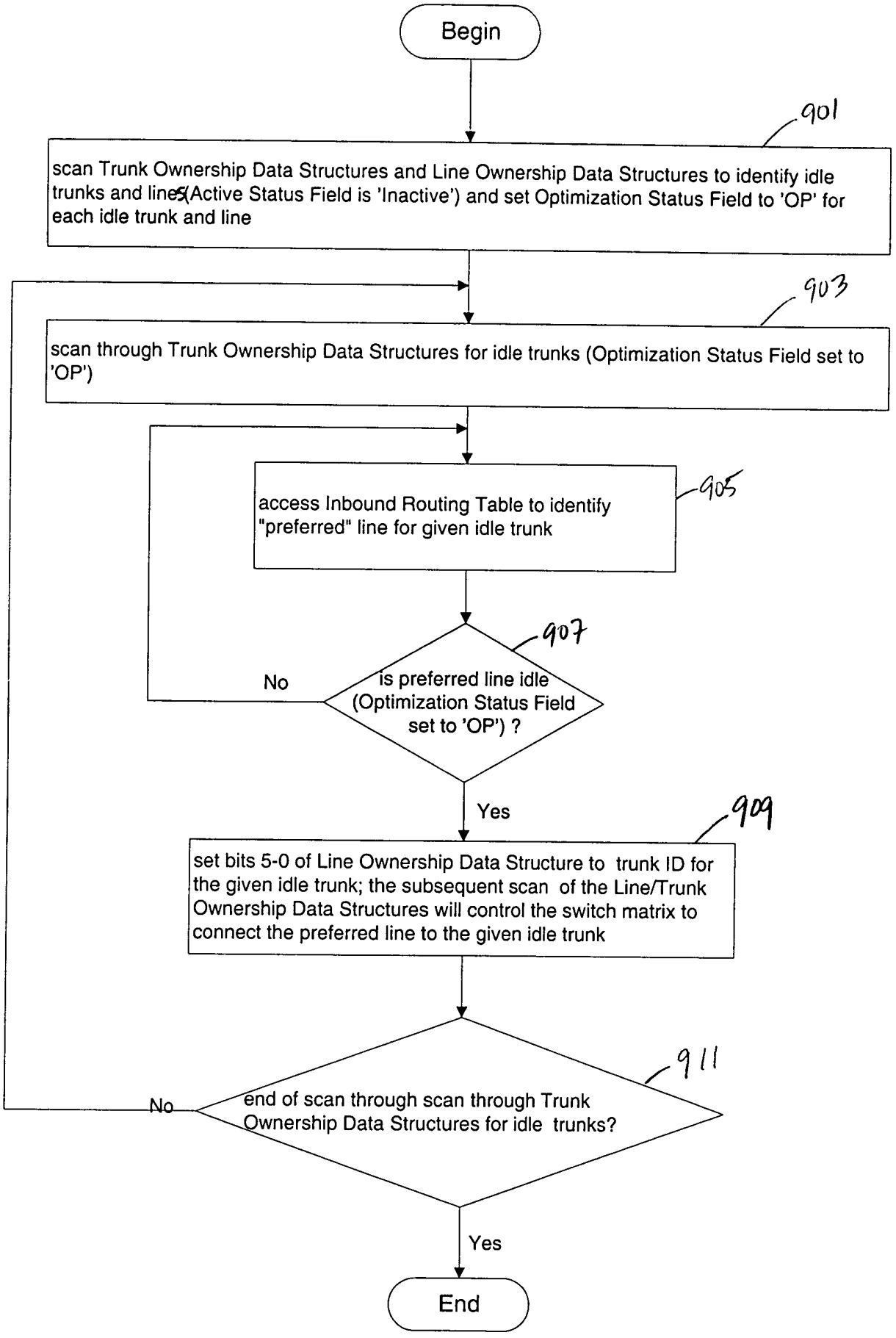

Begin
901
scan Trunk Ownership Data Structures and Line Ownership Data Structures to identify idle trunks and lines (Active Status Field is 'Inactive') and set Optimization Status Field to 'OP' for each idle trunk and line
903
scan through Trunk Ownership Data Structures for idle trunks (Optimization Status Field set to 'OP')
905
access Inbound Routing Table to identify "preferred" line for given idle trunk
907
is preferred line idle (Optimization Status Field set to 'OP') ?
No
Yes
909
set bits 5-0 of Line Ownership Data Structure to trunk ID for the given idle trunk; the subsequent scan of the Line/Trunk Ownership Data Structures will control the switch matrix to connect the preferred line to the given idle trunk
911
end of scan through scan through Trunk Ownership Data Structures for idle trunks?
No
Yes
End

FIG. 10

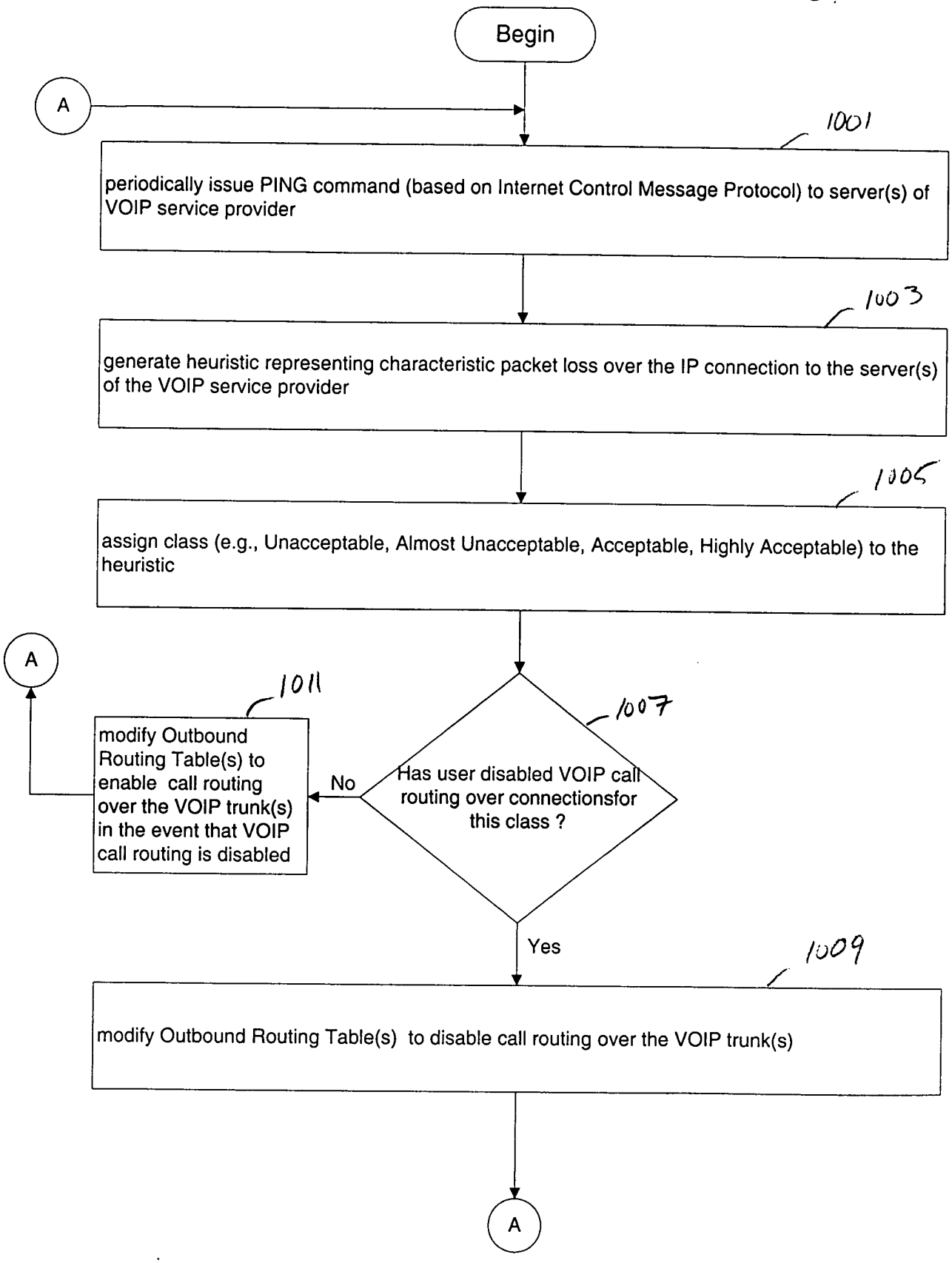

Begin
A
1001
periodically issue PING command (based on Internet Control Message Protocol) to server(s) of VOIP service provider
1003
generate heuristic representing characteristic packet loss over the IP connection to the server(s) of the VOIP service provider
1005
assign class (e.g., Unacceptable, Almost Unacceptable, Acceptable, Highly Acceptable) to the heuristic
1007
Has user disabled VOIP call routing over connectionsfor this class ?
No
1011
modify Outbound Routing Table(s) to enable call routing over the VOIP trunk(s) in the event that VOIP call routing is disabled
A
Yes
1009
modify Outbound Routing Table(s) to disable call routing over the VOIP trunk(s)
A

FIG. 11

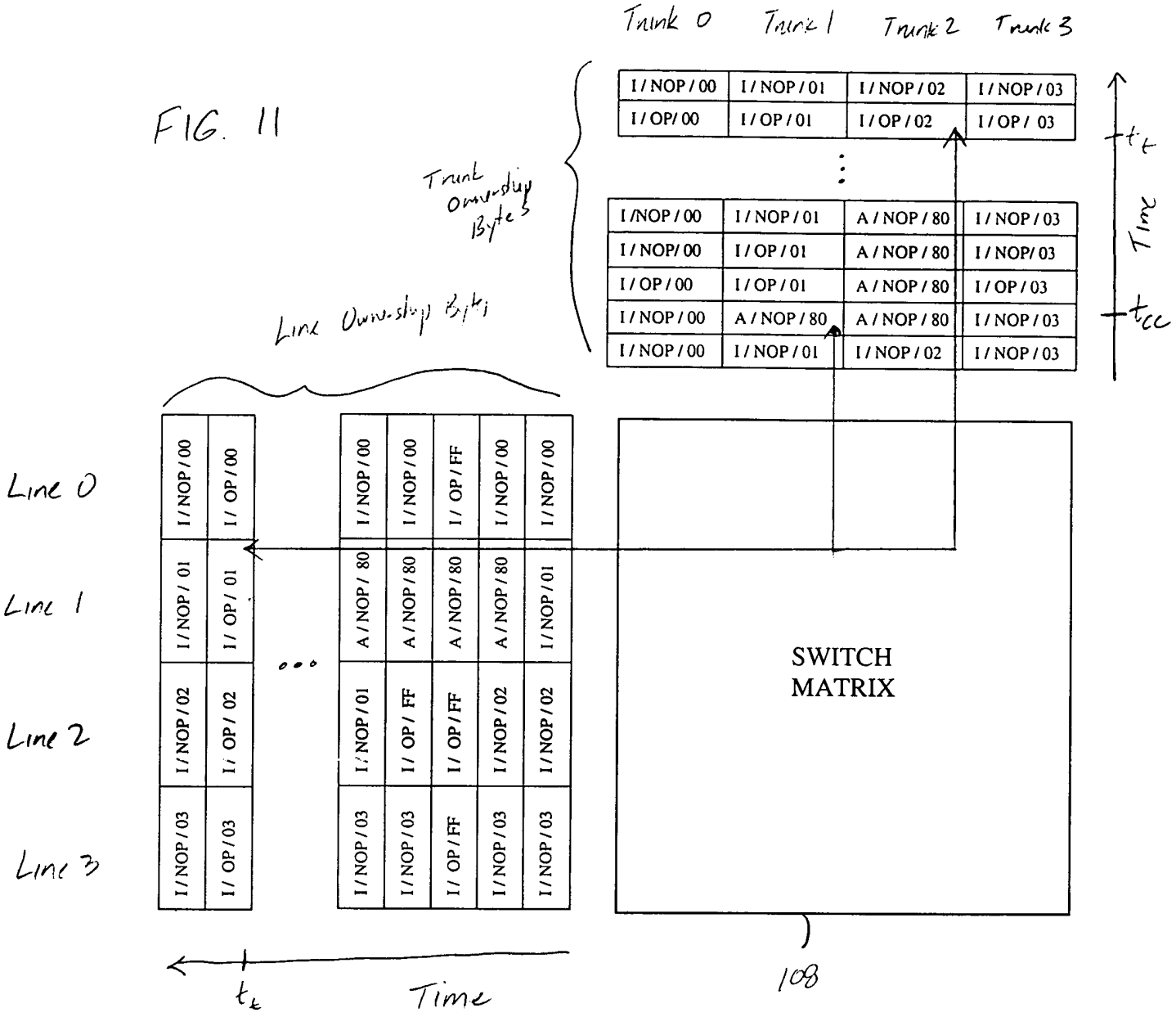
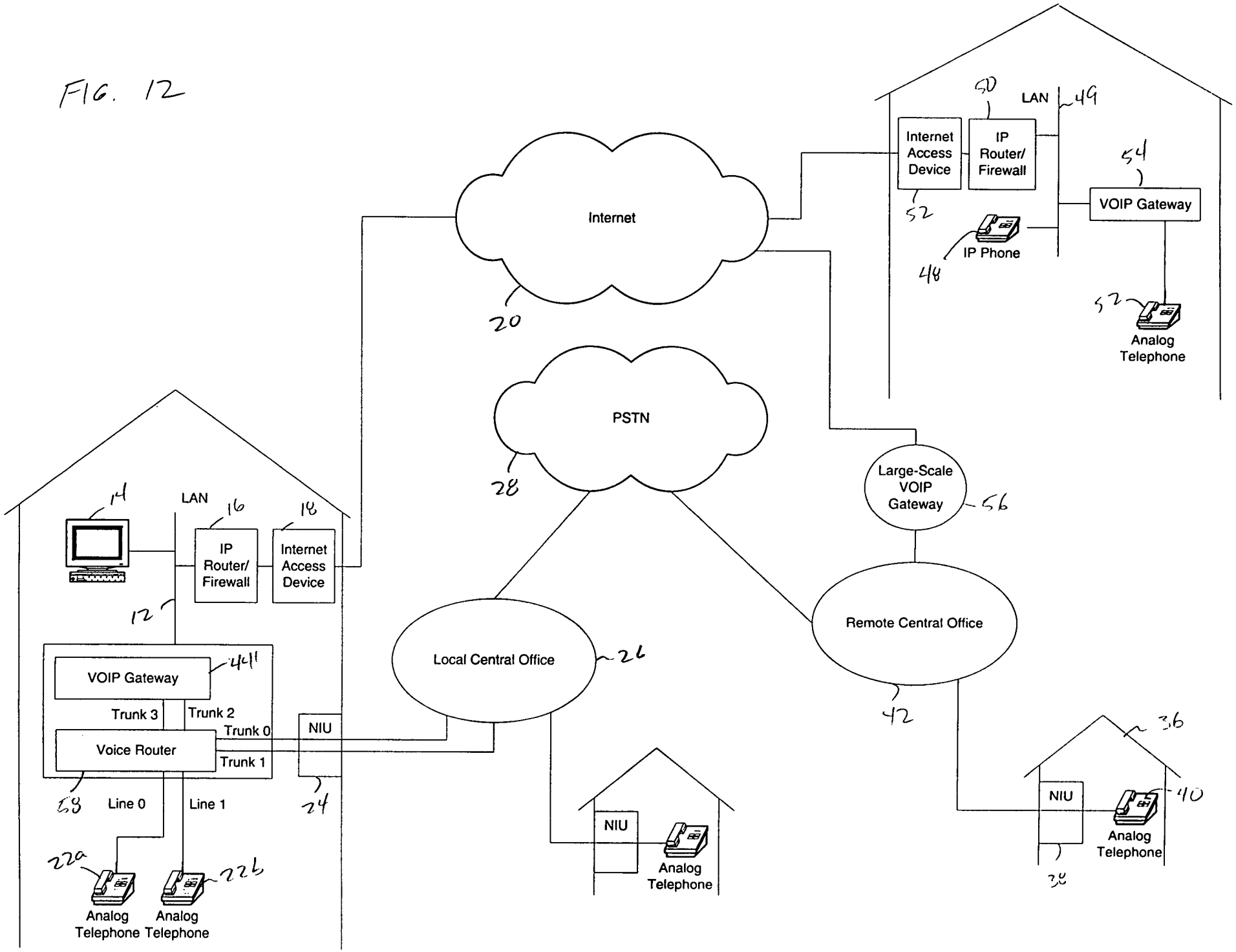

Trunk 0
Trunk 1
Trunk 2
Trunk 3
I / NOP / 00
I / NOP / 01
I / NOP / 02
I / NOP / 03
I / OP / 00
I / OP / 01
I / OP / 02
I / OP / 03
Trunk Ownership Bytes
I / NOP / 00
I / NOP / 01
A / NOP / 80
I / NOP / 03
I / NOP / 00
I / OP / 01
A / NOP / 80
I / NOP / 03
I / OP / 00
I / OP / 01
A / NOP / 80
I / OP / 03
I / NOP / 00
A / NOP / 80
A / NOP / 80
I / NOP / 03
I / NOP / 00
I / NOP / 01
I / NOP / 02
I / NOP / 03
Time
t_t
t_{cc}
Line Ownership Bytes
Line 0
Line 1
Line 2
Line 3
I / NOP / 00
I / OP / 00
I / NOP / 01
I / OP / 01
I / NOP / 02
I / OP / 02
I / NOP / 03
I / OP / 03
A / NOP / 80
I / OP / FF
I / NOP / 00
I / NOP / 01
I / NOP / 02
I / NOP / 03
SWITCH MATRIX
108
t_t
Time

FIG. 12


Internet
20
PSTN
28
LAN
50
49
Internet Access Device
52
IP Router/ Firewall
54
VOIP Gateway
IP Phone
48
Analog Telephone
LAN
14
16
18
IP Router/ Firewall
Internet Access Device
12
VOIP Gateway
44
Trunk 3
Trunk 2
Trunk 0
Trunk 1
Voice Router
58
Line 0
Line 1
NIU
24
22a
22b
Analog Telephone
Analog Telephone
Local Central Office
26
NIU
Analog Telephone
Large-Scale VOIP Gateway
56
Remote Central Office
42
36
NIU
40
Analog Telephone
38

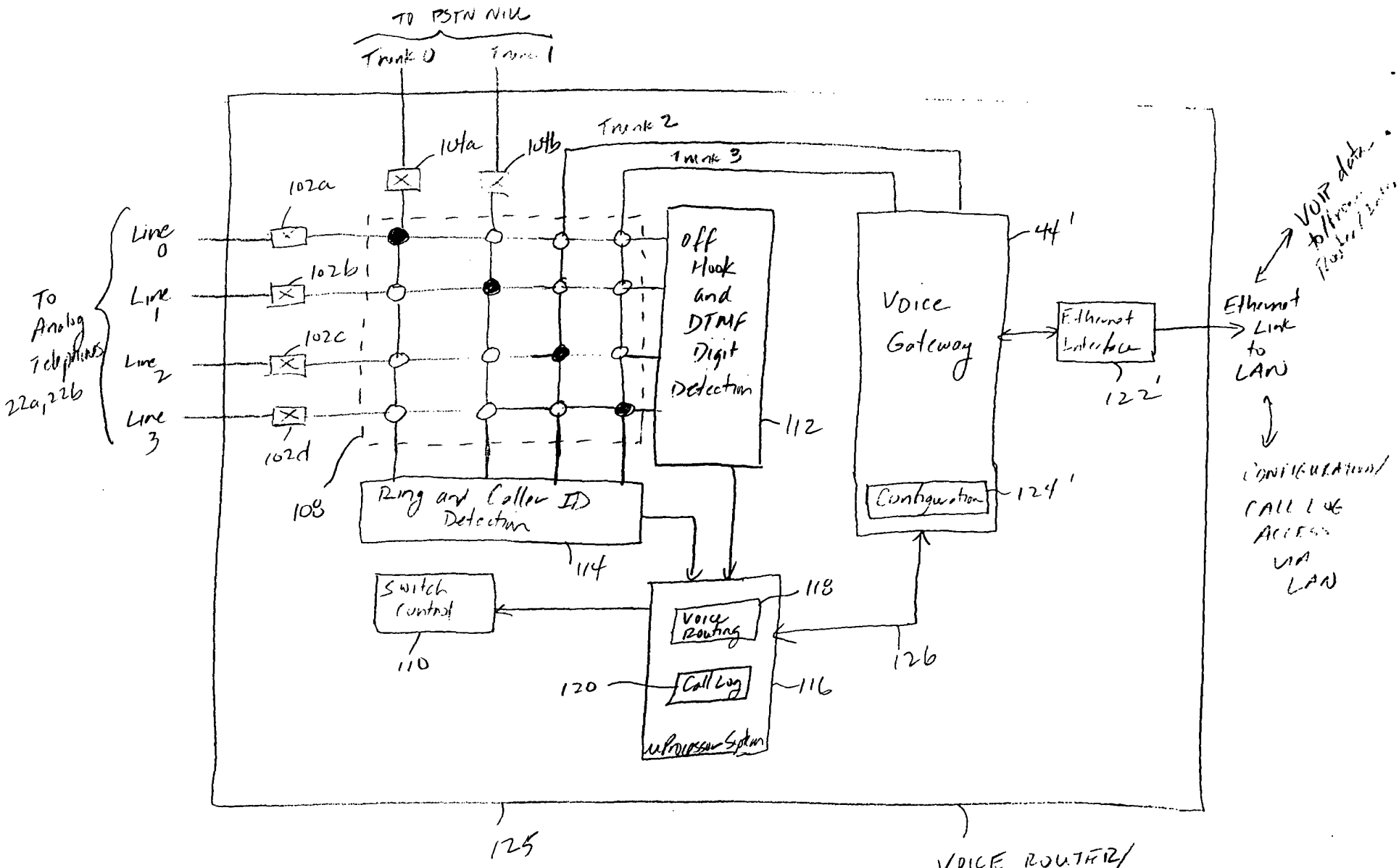

TO PSTN NIU
Trunk 0
Trunk 1
Trunk 2
Trunk 3
101a
101b
102a
102b
102c
102d
Line 0
Line 1
Line 2
Line 3
To Analog Telephones 22a, 22b
Off Hook and DTMF Digit Detection
112
Voice Gateway
44'
Ethernet Interface
122'
Ethernet Link to LAN
VOIP data
CONFIGURATION/ CALL LOG ACCESS VIA LAN
Ring and Caller ID Detection
114
108
Configuration
124'
Switch Control
110
118
Voice Routing
126
120
Call Log
116
Microprocessor System
125
VOICE ROUTER/ GATEWAY

FIG. 13

FIG. 14

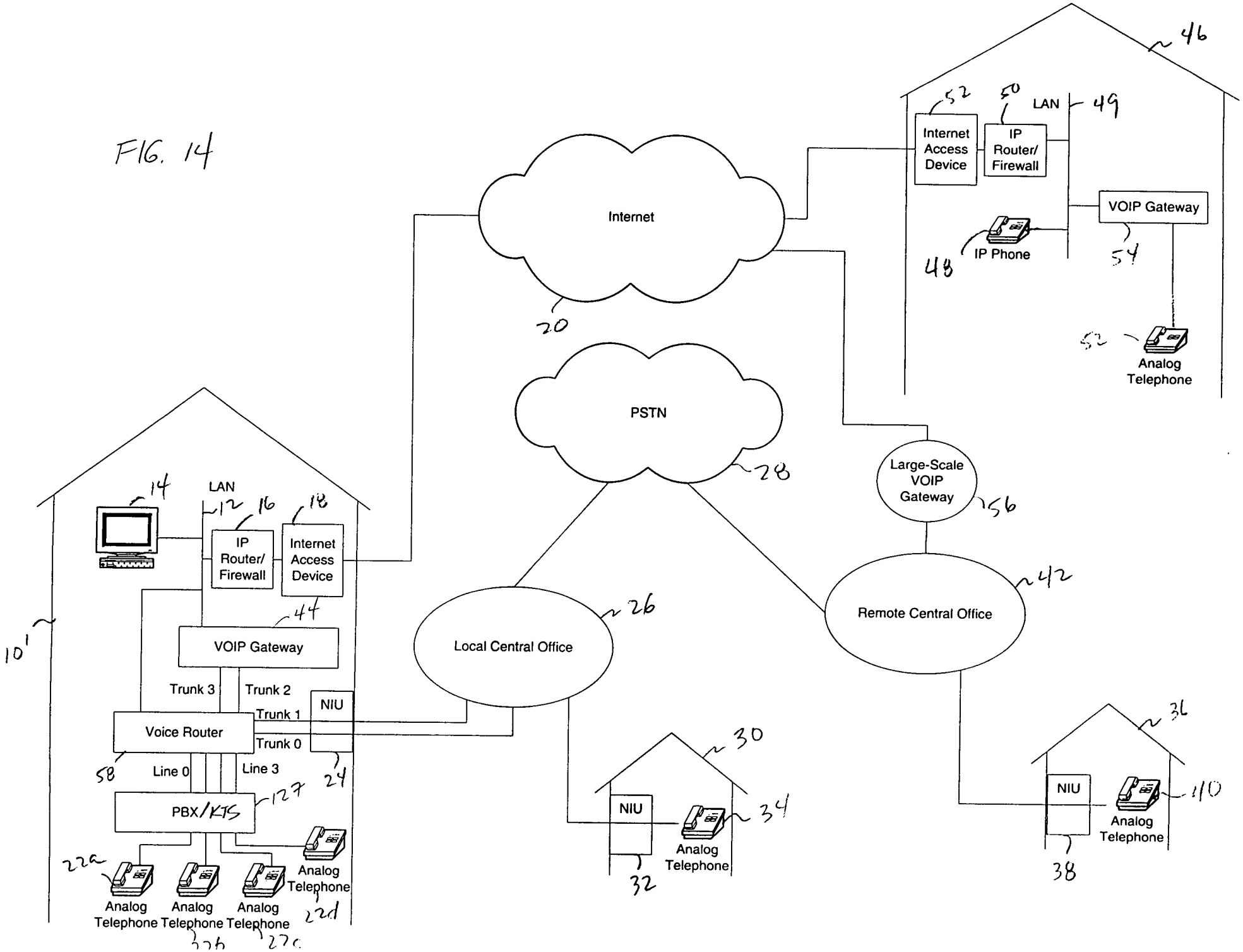
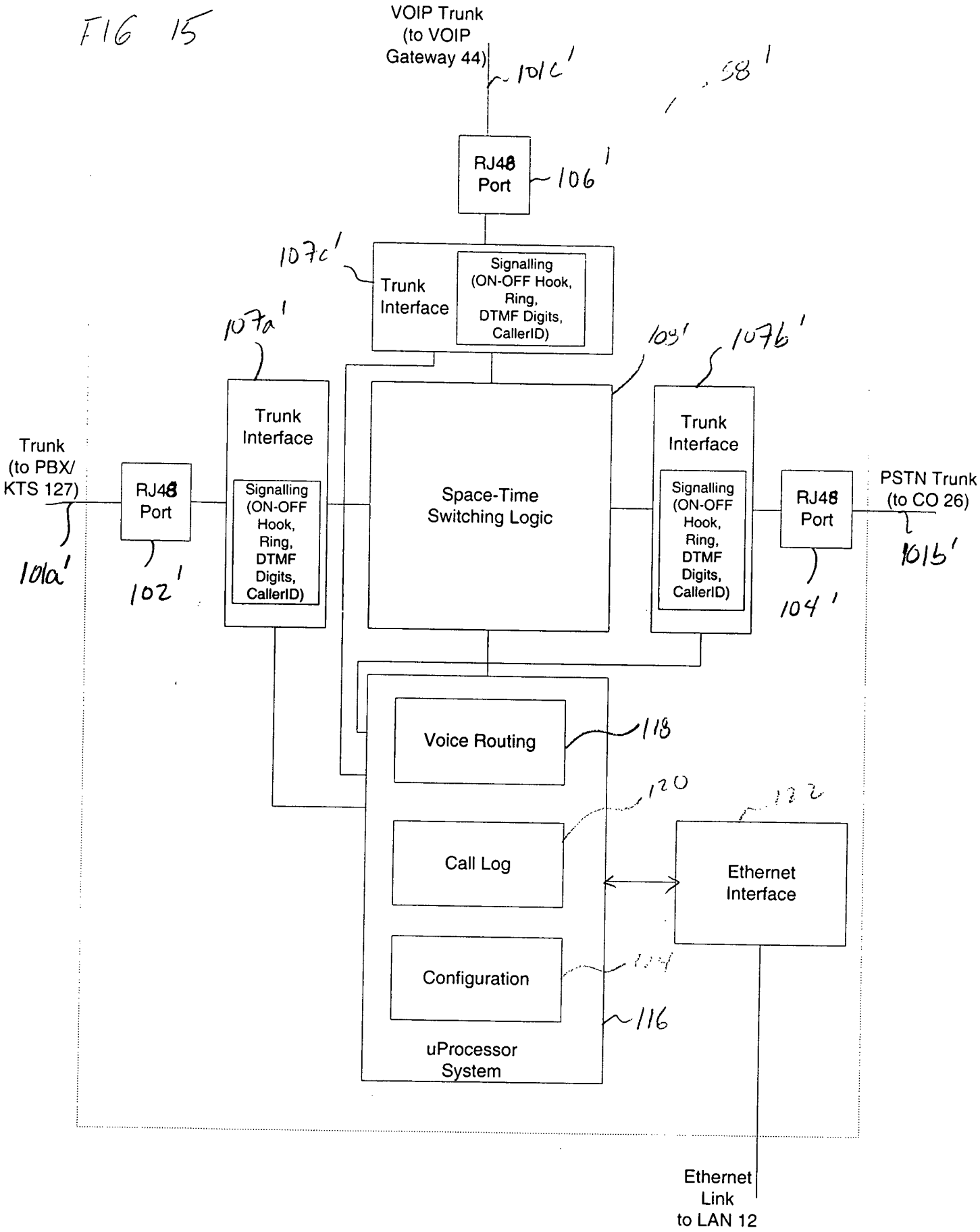

46
52
50
LAN
49
Internet Access Device
IP Router/ Firewall
VOIP Gateway
IP Phone
48
54
Analog Telephone
Internet
20
PSTN
28
Large-Scale VOIP Gateway
56
14
LAN
12
16
18
IP Router/ Firewall
Internet Access Device
44
VOIP Gateway
10'
Trunk 3
Trunk 2
Trunk 1
Trunk 0
NIU
Voice Router
58
Line 0
Line 3
24
127
PBX/KTS
22a
22b
22c
22d
Analog Telephone
Analog Telephone
Analog Telephone
Analog Telephone
Local Central Office
26
Remote Central Office
42
30
NIU
Analog Telephone
34
32
36
NIU
Analog Telephone
110
38

FIG 15


VOIP Trunk
(to VOIP
Gateway 44)
101c'
58'
RJ48
Port
106'
107c'
Trunk
Interface
Signalling
(ON-OFF Hook,
Ring,
DTMF Digits,
CallerID)
107a'
109'
107b'
Trunk
Interface
Space-Time
Switching Logic
Trunk
Interface
Trunk
(to PBX/
KTS 127)
RJ48
Port
Signalling
(ON-OFF
Hook,
Ring,
DTMF
Digits,
CallerID)
Signalling
(ON-OFF
Hook,
Ring,
DTMF
Digits,
CallerID)
RJ48
Port
PSTN Trunk
(to CO 26)
101a'
102'
104'
101b'
Voice Routing
118
120
122
Call Log
Ethernet
Interface
Configuration
114
116
uProcessor
System
Ethernet
Link
to LAN 12